

## H.264 Encoder (v1.14) on DM648/TNETV2685

### FEATURES

- eXpressDSP™ Digital Media (XDM 0.9 IVIDENC) interface compliant
- Validated on the DM648/TNETV2685 EVM
- H.264 baseline profile up to level 3 supported
- Quarter-pel interpolation for motion estimation supported
- In-loop filtering which can be switched off for whole picture and slice boundaries supported
- User controllable multiple slices per picture supported
- Error-robustness features such as intra slice insertion in inter frames, adaptive intra refresh, constrained intra prediction, and forcefully encoding any frame as instantaneous decoding refresh (IDR) supported
- User controllable quantization parameter range supported
- Unrestricted motion vector search, which allows motion vectors to be outside the frame boundary supported
- Image width and height which are non multiples of 16 supported
- TI proprietary rate control algorithms

### supported

- Arbitrary resolutions up to PAL D1 (720x576), including standard image sizes such as SQCIF, QCIF, CIF, QVGA, and VGA supported
- User configurable group of pictures (GOP) length supported
- User configurable parameters such as `pic_order_cnt_type`, `log2_max_frame_num_minus4`, and `chroma_qp_index_offset` supported
- YUV422 interleaved and YUV420 planar color sub-sampling formats supported
- Controls the balance between encoder speed and quality by using the user definable motion estimation settings and encoding Preset option
- Constraint to keep macro block bits within 3200 bits as per the standard not supported

### DESCRIPTION

H.264 is the latest video compression standard from the ITU-T Video Coding Experts Group and the ISO/IEC Moving Picture Experts Group. The H.264 Encoder is validated on the DM648/TNETV2685 EVM with Code Composer Studio version 3.3.24.1 and code generation tools version 6.0.7.



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## Performance Summary

This section describes the performance of the H.264 Encoder on C64x+ (on DM648).

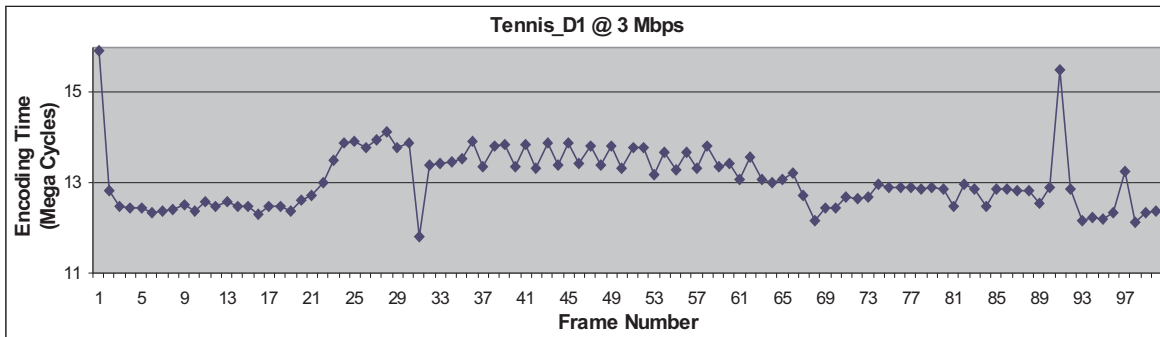
**Table 1. Configuration Table**

CONFIGURATION	ID
H.264 base profile levels 1, 1.b, 1.1, 1.2, 1.3, 2, 2.1, 2.2, and 3	H264_ENC_001

**Table 2. Cycles Information - Profiled on DM648 EVM with Code Generation Tools Version 6.0.7**

CONFIGURATION ID	PERFORMANCE STATISTICS (MEGA CYCLES PER SECOND) <sup>(1)</sup>		
	TEST DESCRIPTION <sup>(2)</sup>	AVERAGE <sup>(3)</sup>	PEAK <sup>(4)</sup>
H264_ENC_001	ti_commercial_720x576.yuv, YUV420/PAL D1 @ 4 mbps with 1 MV, QPI, LPF, UMV-enabled, high quality preset, 100 frames	410	435
	Tennis.yuv, YUV420/704x480 @ 3 mbps with 1 MV, QPI, LPF, UMV-enabled, high quality preset, 100 frames	399	423
	Tennis.yuv, YUV420/704x480 @ 3 mbps with high speed preset, 100 frames	382	399
	mobile.yuv, YUV420/352x288 @ 768 kbps @ 30 fps with 1 MV, QPI, LPF, UMV, high quality preset, 100 frames	123	130
	mobile.yuv, YUV422/352x288 @ 768 kbps @ 30 fps with 1 MV, QPI, LPF, UMV, high quality preset, 100 frames	125	132

- (1) Measured with program memory, stack, and I/O buffers in external memory with cache configuration : 32 K-bytes L1P program cache, and 32 K-bytes L1D data cache, 256 K-bytes L2 cache, 32 bit DDR @ 266.5 MHz, CPU @ 594 MHz and only used by encoder.
- (2) The intra periodicity is 1 second, which means intraPeriod of 30 for 30 fps and intraPeriod of 25 for 25 fps. Rate Control used is IVIDEO\_LOW\_DELAY.
- (3) Based on average number of cycles per frame @ 30 fps, PAL D1 is quoted @ 25 fps.
- (4) Based on worst case cycles on moving average of 4 frames @ 30 fps, PAL D1 is quoted @ 25 fps.



**Figure 1. Encoding Time for Individual Frames (Tennis.yuv, YUV420/704x480 @ 3 Mbps @ 30 fps with 1 MV, QPI, LPF, UMV, and High Quality Preset)**

**Table 3. Memory Statistics - Generated with Code Generation Tools Version 6.0.7 for Level 3.0**

CONFIGURATION ID	LEVEL AND RESOLUTION	MEMORY STATISTICS <sup>(1)</sup>					TOTAL
		PROGRAM MEMORY	INTERNAL	DATA MEMORY		STACK	
				PERSISTENT	SCRATCH		
H264_ENC_001	Level 1.1 QCIF	137	63.25	163	320	8	691.25
	Level 1.3 CIF	137	63.25	456	320	8	984.25
	Level 3.0 PAL D1	137	63.25	1533	320	8	2061.25

(1) All memory requirements are expressed in kilobytes (1K-byte = 1024 bytes) and there could be a variation of approximately 1-2% in values.

**Table 4. Internal Data Memory Split-Up**

CONFIGURATION ID	DATA MEMORY - INTERNAL <sup>(1)</sup>		
	SHARED		INSTANCE <sup>(2)</sup>
	CONSTANTS	SCRATCH	
H264_ENC_001	0	63.25	0

(1) Internal memory refers to L1DRAM. All memory requirements are expressed in kilobytes and there could be a variation of approximately 1-2% in values.  
 (2) I/O buffers not included. Some of the instance memory buffers could be scratch.

**Table 5. Co - Processor(s) Memory Statistics**

CONFIGURATION ID	SEQ DATA MEMORY <sup>(1)</sup>	SEQ PROG MEMORY <sup>(1)</sup>	IMX WORKING MEM <sup>(1)</sup>	IMX IMG BUF <sup>(1)</sup>	IMX CMD MEM <sup>(1)</sup>
H264_ENC_001	1	4	30	5	4

(1) All memory requirements are expressed in kilobytes and all are scratch buffers.

**Table 6. PSNR and Bit Rate Details**

TEST SEQUENCE	BIT RATE RANGE	BIT RATE/AVERAGE LUMA PSNR								
		LOW RATE			MID RATE			HIGH RATE		
		P <sup>(1)</sup>	FD <sup>(2)</sup>	BD <sup>(3)</sup>	P <sup>(1)</sup>	FD <sup>(2)</sup>	BD <sup>(3)</sup>	P <sup>(1)</sup>	FD <sup>(2)</sup>	BD <sup>(3)</sup>
Mobile CIF (352x288), 30 fps		384 kbps			768 kbps			1280 kbps		
	Case 1 <sup>(4)</sup>	24.33	0	4	27.83	0	3.3	30.32	0	2.48
	Case 2 <sup>(5)</sup>	24.51	0	3.27	27.74	0	2.6	30.23	0	0.0
Tennis D1 (704x480), 30 fps		1572 kbps			2560 kbps			4096 kbps		
	Case 1 <sup>(4)</sup>	30.54	0	7.2	31.90	0	5.08	33.30	0	3.1
	Case 2 <sup>(5)</sup>	30.17	0	3.83	31.64	0	2.92	33.16	0	1.89

(1) PSNR in decibels, in case of frame drop, PSNR is measured by repeating previous frame.  
 (2) Number of frame drops.  
 (3) Percentage deviation in bit-rate  
 (4) Rate control used is IVIDEO\_LOW\_DELAY, number of frames are 100, High Quality Preset.  
 (5) Rate control used is IVIDEO\_STORAGE, number of frames are 100, High Quality Preset.

**Table 7. PSNR Comparison with Reference Encoder<sup>(1)</sup>**

TEST SEQUENCE	BIT RATE/AVERAGE LUMA PSNR			
	BIT RATE RANGE	LOW RATE	MID RATE	HIGH RATE
Mobile CIF (352x288), 30 fps		<b>PD<sup>(2)</sup></b>	<b>PD<sup>(2)</sup></b>	<b>PD<sup>(2)</sup></b>
		<b>384 kbps</b>	<b>768 kbps</b>	<b>1280 kbps</b>
	Case 1 <sup>(3)</sup>	0.85	0.44	0.24
	Case 2 <sup>(4)</sup>	0.67	0.54	0.33
Tennis D1(704x480), 30 fps		<b>1572 kbps</b>	<b>2560 kbps</b>	<b>4096 kbps</b>
	Case 1 <sup>(3)</sup>	0.10	0.24	0.24
	Case 2 <sup>(4)</sup>	0.47	0.50	0.38

(1) Reference encoder is JVT version 10.3 configured to use single reference frame, no hadamard, no intra 4x4 prediction mode, no RDO.

(2) PSNR differences of TI encoder and JVT encoder in db.

(3) Rate control used is IVIDEO\_LOW\_DELAY, number of frames are 100, High Quality Preset.

(4) Rate Control used is IVIDEO\_STORAGE, number of frames are 100, High Quality Preset.

## Notes

- Evaluation version performance may be off by up to 30 MHz
- I/O buffers:
  - Input buffer size = 675 K-bytes (D1, one YUV422 interleaved frame)
  - Output buffer size = 150 K-bytes (for encoding one D1 frame)
- Memory Configuration
  - L1P : 32 K-bytes program cache
  - L1D : 64 K-bytes data memory and 16K-bytes data cache
  - L2 : 256 K-bytes cache
- The performances obtained in [Table 2](#) are sensitive to algorithm code placement. Refer the sample linker file provided in the test application setup for algorithm code. placement. This is used for profiling in [Table 2](#).
- The algorithm uses 6 QDMA channels and parameter space equal to 35 parameter entries. The algorithm uses DMAN3 interface for logical allocation of these channels.
- Total data memory for N non pre-emptive instances = Constants + Runtime Tables + Scratch + N \* (Instance + I/O buffers + Stack).
- Total data memory for N pre-emptive Instances = Constants + Runtime Tables + N \* (Instance + I/O buffers + Stack + Scratch).

## References

- ISO/IEC 14496-10:2005 Information technology -- Coding of audio-visual objects -- Part 10: Advanced Video Coding
- *H.264 Baseline Profile Encoder on DM648/TNETV2685 User's Guide*(literature number SPRUF68)

## Glossary

Term	Description
Constants	Elements that go into .const memory section
Scratch	Memory space that can be reused across different instances of the algorithm
Shared	Sum of constants and scratch
Instance	Persistent-memory that contains persistent information - allocated for each instance of the algorithm

## Acronyms

Acronym	Description
CIF	Common Intermediate Format
DMA	DMA Manager
DMAN3	Direct Memory Access
EVM	Evaluation Module
GOP	Group Of Pictures
IDR	Instantaneous Decoding Refresh
LPF	Loop Filter
MV	Motion Vector
QCIF	Quarter Common Intermediate Format
QDMA	Quick Direct Memory Access
QPI	Quarter Pel Interpolation
QVGA	Quarter Video Graphics Array
SQCIF	Sub Quarter Common Intermediate Format
UMV	Unrestricted Motion Vectors
VGA	Video Graphics Array
XDM	eXpressDSP Digital Media

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